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Cold Temperature Conditioning of Conifer Seedlings Prior to Frozen Overwinter Storage

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ABSTRACT

Red pine (Pinus resinosa Ait.), white pine (Pinus strobus L.) and white spruce (Picea glauca (Moench) Voss) seedlings were lifted for storage on five fall dates and subjected to five cold conditioning treatments. Cold conditioning significantly improved field performance of stock lifted early but had no effect on later lifts. Moulding was more the result of early lifting than storage temperature.

Introduction

Successful frozen overwinter storage of coniferous nursery stock is dependent upon sound lifting, handling and packaging practices. This includes lifting at the appropriate time in the fall as determined by number of degree hardening days (Mullin and Parker 1976) or, more recently, using electrical impedance values. Stock can be conditioned either before lifting by nursery bed preparation to prevent premature freezing (Mullin and Hutchison 1979) or after lifting by heeling in of lifted stock to permit completion of the natural hardening-off process (Mullin and Bunting 1977). Another method of conditioning prior to storage consists of lifting the stock, packaging it for overwinter storage and subjecting the stock to temperatures just above the freezing point for a period of time prior to freezing at -3°C.

This report examines the influence of five dates of fall lifting and five lengths of cold temperature treatments prior to frozen storage on stock survival and height growth after outplanting.

Materials and Methods

White pine (Pinus strobus L.), red pine (Pinus resinosa Ait.) and white spruce (Picea glauca (Moench) Voss) seedlings were lifted at Midhurst Nursery (44°27'N. Lat., 79°44'W Long.) during each of five fall lifts prior to overwinter frozen storage (Table 1). At each lifting date, for each species and for each of five conditioning treatments (Table 2), 100 seedlings were hand lifted and packed in five bundles of 20 trees along with a handful of damp moss, in one kraft paper bag with a polyethylene liner. The five bags per species were treated as described in Table 2. Subsequently, all trees were frozen stored until early May, when they were removed from frozen storage 48 hours prior to outplanting on a single sandy loam site.

TABLE 1 Lift number, lifting date and accumulated degree hardening days (DHD) in two of the compartments from which trees were lifted at Midhurst Nursery. The red pine and white pine were lifted from compartments K-3 and K-4 respectively and the white spruce was lifted from compartment A-13. The DHD values from compartment K-4 should be very similar to those in the adjoining compartment.

Lift	Date	DHD	
		A-13	K-3
1	Sept 27, 1983	5	4
2	Oct 11, 1983	19	14
3	Oct 25, 1983	81	67
4	Nov 8, 1983	184	163
5	Nov 22, 1983	308	288

TABLE 2 The five conditioning treatments.

Treatment code	Description
F	Stock placed directly into frozen storage at -3°C
C1F	Stock in cold storage (1°C) for 1 week before frozen storage
C2F	Stock in cold storage for 2 weeks before frozen storage
C3F	Stock in cold storage for 3 weeks before frozen storage
C4F	Stock in cold storage for 4 weeks before frozen storage

Prior to planting, trees were examined for the presence and extent of mould. The white spruce, white pine and red pine were planted May 4, May 7 and May 11 respectively. Outplanting was done in a randomized complete block split plot design with five replications, five fall lifts as main treatments and five conditioning sub-treatments of 20 trees each. Simazine was applied around the base of each tree at a rate of 10 kg/ha for weed control during the course of the experiment.

Second year survival, height and annual increment were measured and subjected to an analysis of variance. Significant differences among treatments were determined with Duncan's New Multiple Range Test.

Results and Discussion

The incidence of mould was serious on stock of earlier lifts but was not affected by length of conditioning (Table 3), despite the fact that extent of moulding is influenced greatly by storage temperature (Nyland 1974 and Venn 1981). Moulding can probably be minimized as long as the temperatures within the containers can be lowered to -3°C soon after the required cold storage period (1°C) has been achieved. Storage containers have a substantial temperature buffering capacity which can be modified by the configuration of the storage facility, good air circulation and open stacking. Moulding can accelerate if prolonged periods at above freezing temperatures prevail due to lack of control over internal temperature (Nyland 1974, Venn 1981, Racey et al. 1984, Racey et al. 1985).

The field performance of all three species regardless of conditioning was primarily dependent upon date of lifting (Table 4). Lifting prior to an accumulation of 67 DHD (°C) produced, in most cases, unacceptable height growth and survival. Lift 3 produced good field performance even though the degree hardening day requirements for white pine (165 DHD) (Racey et al. 1985), red pine (185 DHD) (Mullin 1980) and white spruce (115 DHD) (Mullin

TABLE 3 Extent of moulding during storage for each lift and treatment: 0/ no mould, 1/ very minor, noticeable by careful inspection only, 2/ visible without careful inspection, usually in root collar area, 3/ obvious, usually over tops and roots, 4/ extensive mould throughout tops and roots of trees, and 5/ extensive mould throughout, needle discolouration, foul odour.

Lift	Treatment	White pine	Red pine	White spruce
1	F	3-4	0	4-5
	C1F	3-4	1	4-5
	C2F	3	1	4-5
	C3F	3	0	4-5
	C4F	2-3	0	4-5
2	F	1	1	3
	C1F	1	1	2-3
	C2F	1	0	3
	C3F	1	0	3
	C4F	1	0	3-4
3	F	0	0	2-3
	C1F	0	0	2-3
	C2F	0	0	2-3
	C3F	0	0	3
	C4F	0	0	2-3
4	F	0	0	0
	C1F	0	0	0
	C2F	0	0	1
	C3F	0	0	1
	C4F	0	0	2
5	F	0	0	0
	C1F	0	0	0
	C2F	0	0	0
	C3F	0	0	0
	C4F	0	0	1

and Parker 1976) were not met. Longer conditioning, irrespective of time of lifting, increased survival of all three species and height growth of white spruce and red pine (Table 4).

The largest influence of conditioning was on survival of the stock lifted before it was fully hardened off, that is, in the early lifts (Figs. 1-3). A similar but less pronounced effect of conditioning was observed in the second year height measurements (Table 4). No advantage due to conditioning was observed in stock lifted after it was ready for direct frozen storage.

TABLE 4 Second year heights, terminals and survival of 3 species overwinter frozen stored (-3°C) after various cold treatments (1°C). Numbers followed by the same letter are not significantly different at the 5% level.

Treatment	Height (cm)	Current annual increment (cm)	Survival (%)
White pine			
Lift 1	N.D.	N.D.	14 c
Lift 2	32.1 b	12.1 b	66 b
Lift 3	31.5 b	12.8 b	96 a
Lift 4	35.2 a	15.5 a	97 a
Lift 5	37.4 a	15.5 a	97 a
	***	***	***
F	32.2	13.2	65.0 c
C1F	33.6	13.8	75.6 b
C2F	35.1	13.9	74.8 b
C3F	34.5	14.6	86.8 a
C4F	34.8	14.3	91.3 a
	N.S.	N.S.	***
Red pine			
Lift 1	N.D.	N.D.	2 d
Lift 2	29.0	4.3 b	53 c
Lift 3	32.0	7.0 a	93 a
Lift 4	32.4	4.7 b	89 b
Lift 5	31.6	5.1 ab	92 ab
	N.S.	*	***
F	28.8 b	5.3	57 b
C1F	30.9 ab	4.4	58 b
C2F	32.2 ab	5.5	70 a
C3F	31.8 ab	5.4	70 a
C4F	32.8 a	5.9	79 a
	*	N.S.	***
White spruce			
Lift 1	N.D.	N.D.	1 c
Lift 2	31.4 b	7.3 b	55 b
Lift 3	39.0 a	9.0 ab	93 a
Lift 4	39.5 a	10.3 a	96 a
Lift 5	41.5 a	10.5 a	91 a
	***	**	***
F	36.7 b	9.9 a	58 c
C1F	36.5 b	9.7 ab	71 ab
C2F	38.0 ab	8.6 b	67 bc
C3F	38.5 a	8.6 b	69 ab
C4F	39.7 a	9.6 ab	76 a
	***	*	***

N.D. No data available because nearly all trees died
N.S. No significant differences
* Statistically significant at the 5% level
** Statistically significant at the 1% level
*** Statistically significant at the 0.1% level

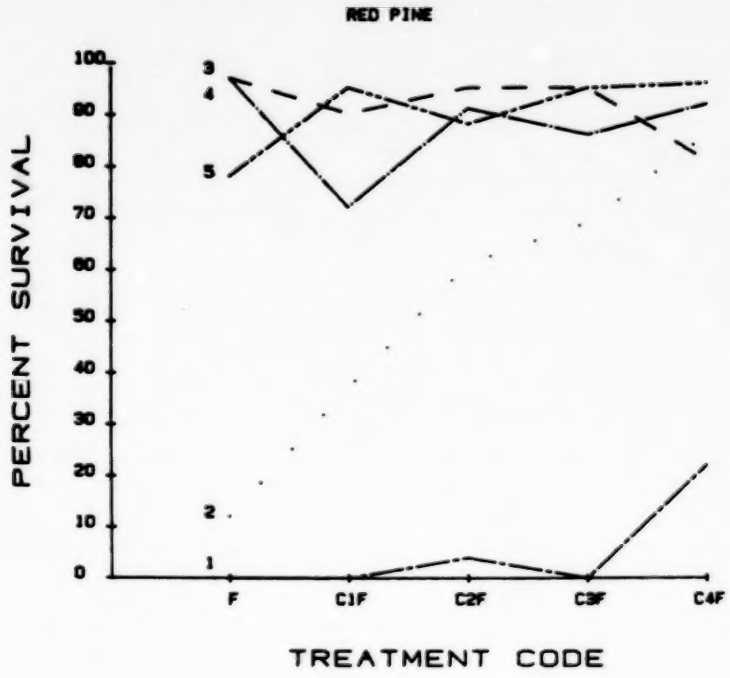

Figure 1 Second year survival of 3+0 red pine from 5 fall lifts and 5 fall conditioning treatments. For key of treatment types see Table 2.

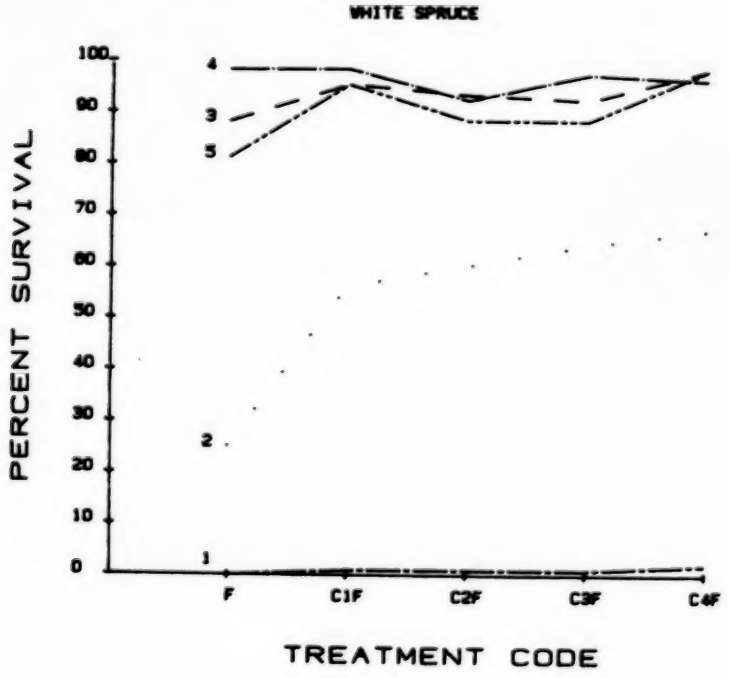

Figure 2 Second year survival of 3+0 white spruce from 5 fall lifts and 5 fall conditioning treatments. For key of treatment types see Table 2.

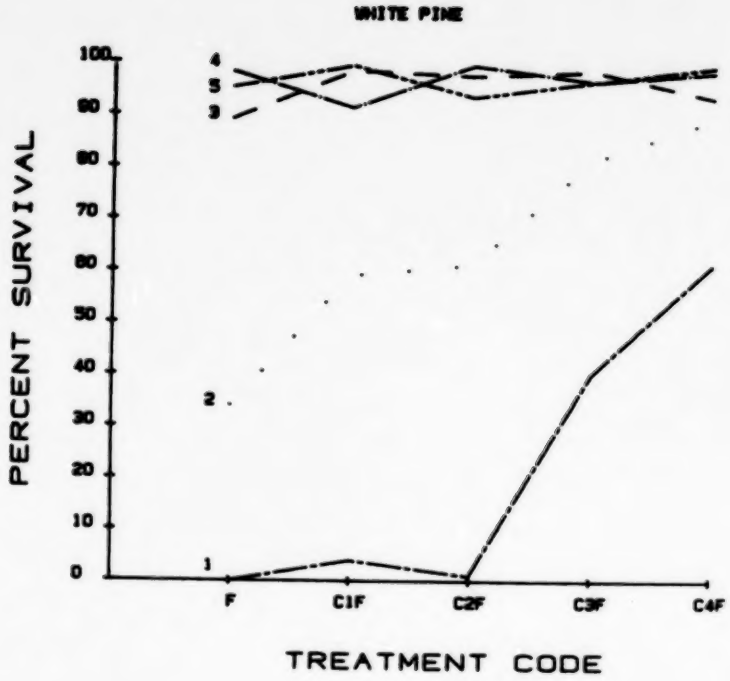

Figure 3 Second year survival of 3+0 white pine from 5 fall lifts and 5 fall conditioning treatments. For key of treatment types see Table 2.

Conclusions

Temperature conditioning of fall lifted stock prior to storage is not necessary to ensure good field performance of frozen overwinter stored white pine, red pine and white spruce. However, when in doubt that stock is ready for lifting for storage, temperature conditioning may be recommended. This includes a cold storage (1°C) treatment of three weeks, prior to frozen storage. Frozen storage (-3°C) is still considered the best artifical overwintering method for bare root stock provided that good temperature control in the storage facility allows rapid lowering of the internal container temperatures to -3°C.

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